VEIN FORMATION AT COBALT, ONTARIO

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VEIN FORMATION AT COBALT, ONTARIO

By

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At the meeting of the Canadian Mining Institute, held in Toronto last spring, Dr. C. R. Van Hise, of Madison, Wisconsin, delivered an instructive address on "The Ore Deposits of the Cobalt District," in which he emphasized the facts already pointed out by Messrs. Campbell, Knight, and others, that there is a distinct and regular sequence in the order of segregation of the various ores in the veins, the cobalt and nickel ores being segregated out first, while the silver ores were introduced at a later date.

Speaking of the silver ores, and of the probability that they again might have been introduced at two separate and distinct periods of time, he said: "To what extent are the rich deposits the result of one segregation under comparatively deep-seated conditions, and to what extent of two segregations, one under deep-seated, and the other under shallow conditions? Did the shattering which resulted in the entrance of the silver solutions occur under deep-seated conditions, so that the silver of the rich shoots was deposited as a closing episode of practically one continuous period of concentration? Or, after the first concentration was complete, did the shattering then occur, and the later enrichment take place under comparatively shallow conditions, the two periods of concentration being separated by a long interval? Whatever is the final answer to the above question, it appears certain that the extremely rich superficial deposits of a few feet in thickness, connected directly with the zone of weathering, are due to secondary concentration under surface conditions. I refer to the nugget horizon, which is so rich in silver, and in which the smaltite and cobaltite have been largely altered into secondary minerals, or have been leached out altogether. It is practically certain that this extraordinarily rich upper film in the Cobalt district has been produced by two concentrations, one under deep-seated conditions, when atmospheric waters were not present, and the other under surface conditions, when atmospheric waters were present."

Again, "I believe that the extremely rich upper silver belt, so characteristic of the district, is unquestionably the result of two concentrations, the latter of which is accomplished through the agency of atmospheric waters."

Thus two distinct periods of time are here clearly designated for the deposition of the silver ores, namely, an earlier one under deep-seated conditions away from the presence of atmospheric influences, and a later one under surface conditions, though both of these segregations are secondary as compared to the prior segregation of the cobalt and nickel ores.

Dr. Van Hise also agrees with Professor Miller and others that the post-Huronian diabase which is known to underlie large areas within the district is the original source of the ore, and also that this diabase has the form of a horizontal sill or laccolith, rather than of a series of huge dikes or batholitic masses which spread out and increase in size as they descend, and that it rose through fissures or vents in the older rocks of Keewatin, Laurentian, or Huronian age, until it reached and was stopped by some more resistant layer, through which it was unable to penetrate, and so was forced to spread out horizontally beneath it.

Professor Miller has also shown, in a paper published in the first number of this JOURNAL, that the mineral-bearing veins "appear to have been formed when the cooling of the diabase was taking place. On cooling, the diabase would contract, producing fissures, not only in its own mass, but also in the rocks with which it was in contact, or which lay adjacent to it."

It will be interesting to consider some of the effects on the form and richness of the mineral-bearing veins of the Cobalt district which would seem to follow as natural and logical results from the conditions outlined above. If the conclusions here reached do not harmonize with the conditions that may be found to occur in the mines by the managers and superintendents who are operating them, any corrections and emendations will be gladly welcomed.

At the time when the laccolith was being formed the molten diabase, after rising for a certain distance through the older and already consolidated rocks, would seem to have met a more resistant layer which obliged it to spread out horizontally along planes of weakness in these rocks and form extensive flat-lying sheets. By the injection of this fluid sheet or lens the superincumbent rock was raised to a certain extent.

The liquid diabase was, of course, very hot, and the heat from it was communicated to the rocks above and below it, and these in their

turn would expand with the increase in temperature, but on account of difference in texture and composition the heat would be absorbed differently by different bands, and the expansion would consequently be unequal, so that joints, fissures, and shearing planes would be formed.

After the intrusion of the diabase had ceased, it would gradually begin to cool and harden. As it cooled it would contract, and fissures would form in the parts that had consolidated, but while there was any portion of the mass still fluid these fissures would probably be filled from the fluid interior. The fissures occupied by the present veins were therefore formed subsequent to the solidification of the whole mass.

After the mass had solidified, as it and the adjoining rocks gradually cooled they would necessarily contract, the contraction amounting to about 9 inches in 1,000 linear feet for every decrease of 100 degrees centigrade in temperature. This contraction would cause the formation of many irregular fissures normal to the plane of heating and cooling, or in this instance approximately vertical. The fissure would be widest and most extensive either in the diabase itself, or in the surrounding rock wherever this was in immediate contact with the diabase, where the heat had been most intense, and where the subsequent cooling and consequent shrinkage was also greatest.

The rock above the laccolith, extending from it to the surface of the earth, would lose its heat and cool comparatively quickly, and on this account it is hardly probable that it became very hot to any great distance from the diabase. Therefore the cracks and fissures that were formed by contraction on cooling in the thin heated layer near the diabase, and that extended outwards more or less at right angles to it, would all be short and very shallow. They would, of course, be widest close to the diabase where the heat and subsequent decrease in temperature had been greatest, and would quickly contract and disappear altogether at a short distance from it. If mineral-bearing solutions in ascending from the heated interior of the earth reached this zone, the fissures were probably filled by such minerals as are known to have been deposited first throughout the district, such as calcite, smaltite, cobaltite, niccolite, etc., but the silver ores which are here the products of a later segregation, would probably be absent.

The rocks that underlay the diabase, whether Keewatin greenstone, Laurentian granite or Huronian conglomerate, would be heated by it like the rocks above it, but as the cooling took place largely by radiation of heat from the surface of the earth, and the laccolith

now lay between these underlying rocks and the surface, the cooling would progress exceedingly slowly, in fact it would not begin at all until the laccolith itself had cooled to the temperature of the rock below it. Then this lower rock would begin to cool and shrink, and as the shrinking continued numerous fissures would be formed, which in the aggregate would certainly be widest and most extensive close to the contact with the overlying diabase, and would pinch out and disappear as they descended, or as they went farther and farther from the diabase.

To what depth the rock was affected by the heat from the diabase and by its subsequent cooling is not known, but it will be a matter of great interest to determine, as the fissures occupied by the veins may be expected to extend to that depth.

As clearly shown by Dr. Van Hise, the fissures so formed in this zone of shrinkage were first filled by calcite and ores of cobalt and nickel by precipitation or deposition from solutions that had risen from deep-seated sources during the later stages of the diabase eruption, and had circulated outwards through cracks and crevices as far as the influence of the diabase intrusion had reached. These minerals now make up very much the largest part of the contents of the veins, so that the veins were formed almost to their present size, and the walls were almost as far apart as they are now, and consequently the adjoining rock had cooled almost to its present temperature, while this early stage of ore deposition was in progress.

As an accompaniment to the very last stages of the diabase intrusion, silver-bearing solutions rose from deep-seated sources along the igneous vents and spread through and under the mushroom-shaped laccolith along the fissures and veins as these widened slightly with the final cooling and shrinking of the rock, the process being continued until all the channels for the passage of the rising waters were choked.

The veins thus fill V-shaped fissures which extend downwards unknown distances below the bottom of the laccolith, or the former position of the laccolith, and in the aggregate become narrower as they go down.

In applying this rule, however, it should be observed that any individual fissure may be only a part of a complex imbricated series, so that, while one may contract, another to one side or the other of it may widen to an almost corresponding degree. The rapid pinching out of one vein in depth should not, therefore, lead to the belief that the bottom of the zone of shrinkage had been reached, but should rather lead to exploration for other so-called "blind veins" in the vicinity.

After the veins had thus been formed by segregation from waters of magmatic, or at all events of deep-seated origin, there was a very long period of time during which the earth's surface was here subjected to the influence of atmospheric agencies, and was gradually eroded away. Much of the rock which originally covered the diabase laccolith was thus removed, and doubtless large blocks of the diabase itself were also worn away, uncovering the rocks which underlay it over areas of unknown extent. At the same time many veins holding ores of cobalt and silver were cut into, and exposed to meteoric influences, so that the oxygenated surface waters percolated downwards into them, and leached the silver from their decomposed uppermost portions, re-depositing it a little lower down near the zone of ground-water. This process went on continuously as the surface was gradually removed, and the level of ground-water was lowered, and in this way an abnormally rich zone was constantly present in the veins a short distance below the surface. This is the later "secondary enrichment" spoken of by Dr. Van Hise.

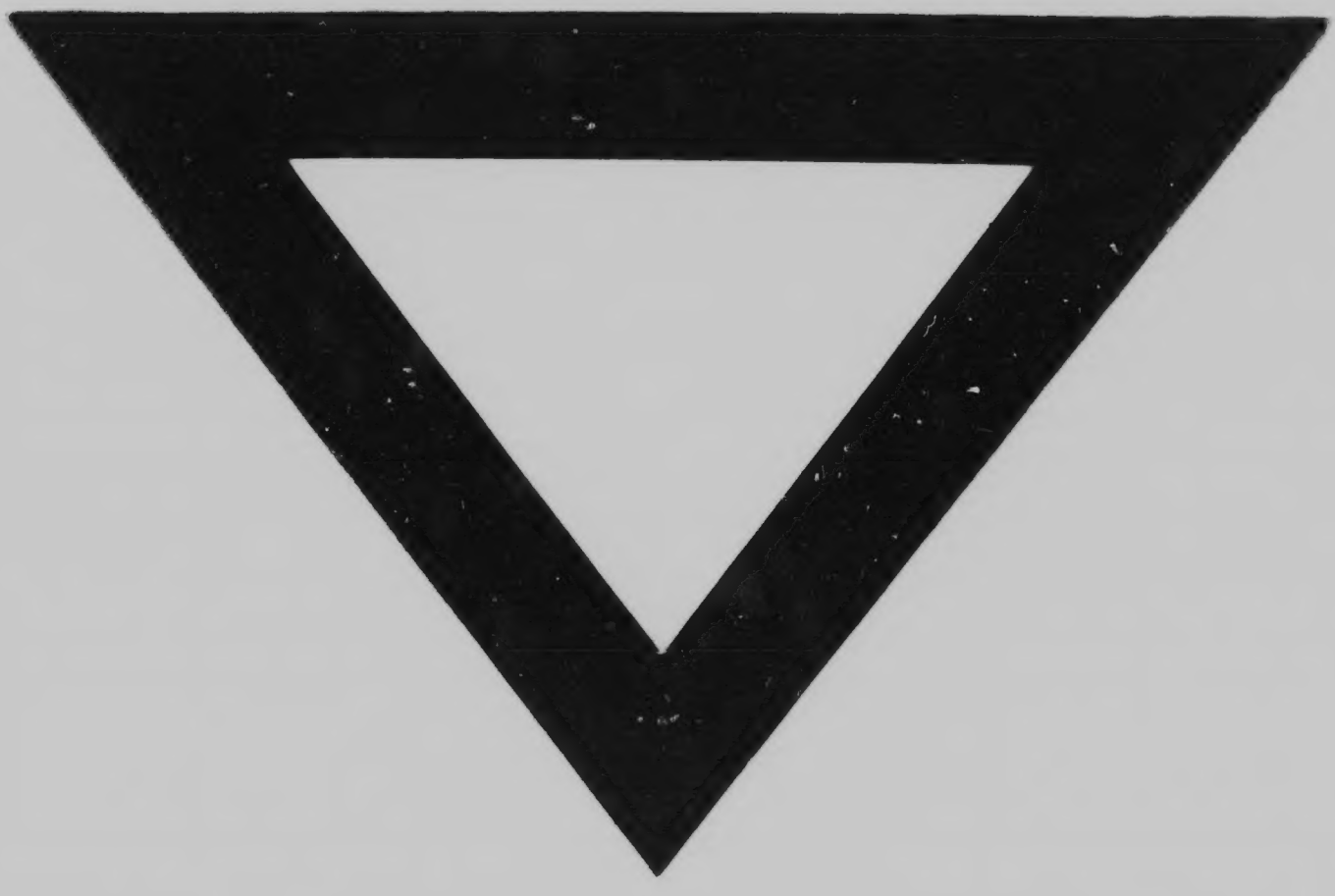
As the long period of denudation was drawing to a close, during which erosion, solution, and concentration had been almost constantly at work, the Glacial period set in. A vast sheet of snow and ice then moved southward across the country, and cleaned off and swept away the decomposed rock that for long previous ages had everywhere formed the uppermost layer of the surface of the land, and left the greatly enriched parts of some of the veins either exposed to view, or merely covered by a thin layer of boulder clay.

In summing up the evidence, more especially in regard to the veins in the conglomerate and other rocks beneath the diabase, it would thus appear:—

That these cobalt and silver veins were formed in V-shaped fissures which taper from above downwards;

That though they were formed by mineral-bearing waters which rose from deep-seated sources, and were associated with the latest stages of the eruption of diabase, having probably risen through the same vents with it, these waters spread out laterally through cracks and openings in the mushroom-shaped top of the laccolith of diabase, and descended into the fissures in the rocks beneath it;

That thus the veins were originally formed by deposition from waters which locally descended from above, rather than ascended from below, as in most normal veins;

And finally, that the veins were superficially enriched at a later period by atmospheric waters descending through portions of the veins which have since been eroded away.

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